Voyager Mission Support (I)

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This article is a continuation of the Deep Space Network report on tracking and data acquisition for Project Voyager. This article covers the period July through 11 August 1981.

I. Introduction

Voyager 1 was in the extended mission phase of operations during this reporting period. Voyager 2 completed the Observatory phase of the Saturn Encounter on 31 July and the Far Encounter-1 (FE-1) phase on 11 August. It is now in the Far Encounter-2 (FE-2) phase in preparation for the nearest approach on 26 August.

II. DSN Support

A. Voyager 1

The extended mission phase continued for Voyager 1, with the 26-meter-antenna net providing the majority of the tracking support. However, 34- and 64-meter support was provided as required, as on the Navigational Cycle (Nav Cycle) performed on 20/21 July. This Nav Cycle was performed with only three-station coverage; the previous cycles had employed four-station coverage (two tracks by the Australian stations). The tracking loop capacitor (TLC) test continued to be run weekly as was the transmission of a dummy computer command (CC) to prevent the spacecraft from going into the emergency routine when a command had not been received for a specified period.

Radio Science return was received during the XSCEL (X-band Saturn Celestial Mechanics) activity in the form of Saturn system celestial mechanics study, gravitational red shift determination, and ultrastable oscillator frequency check. The activity was conducted biweekly. Periodic Engineering and Science Calibration (PESCAL) activities were supported bimonthly.

B. Voyager 2

1. Operational Readiness Test B-2. On 1 July, the Radio Science Operational Readiness Test B-2 was conducted with DSS 43. A command load was put into the spacecraft to simulate the closest approach conditions so that the encounter Radio Science sequence could be exercised to validate procedures and end-to-end support system operation. The test was very successful and the major objectives were met. Some minor problems were identified that required corrective actions. On 5 August, a mini-ORT was conducted to test the system again and verified the corrections and procedures as applicable for the problems identified in the ORT.

2. Radio Science Operational Verification Tests. During the reporting period, DSS 43 Radio Science capabilities were exercised by conducting five Operational Verification Tests (OVTs). The OVTs primary objectives were to insure that the equipment remained operational, configurations were valid, and personnel were trained and ready to support the Radio Science activity during the Saturn closest approach. Although some minor problems were experienced during the testing, indications generally were that the equipment and personnel were ready to support the actual encounter operation satisfactorily.

The primary problem was the implementation of the Precision Power Monitor (PPM) capability to monitor the system noise temperature (SNT) of all four receiver systems (two S-band and two X-band). Although the system was installed, continued proper operation could not be achieved. Two engineers from JPL were dispatched to the station to assist in correcting the problems.

DSS 43 also experienced problems with the Radio Science wideband recorders due to excessive bit error rate (BER). The problem was isolated and corrected by the use of high quality tapes. With proper alignment, new analog-to-digital converters were installed and the operation validated during operational testing.

It was felt that some of the recorder problems could be attributed to the recording tape being used. To overcome this possibility, special, validated and certified tapes (Ampex 799) were shipped to the station to be used for specified test periods and for the actual Near Encounter Radio Science activity. Use of the tapes has generally improved recorder operation.

3. Trajectory Correction Maneuver B-8. On 19 July, a trajectory correction maneuver was performed by Voyager 2 to position the spacecraft at Saturn closest approach at approximately 161,000 km from the center of the planet. The maneuver was executed by roll and yaw turns to place the spacecraft on the burn axis, which placed the spacecraft off earth-point. The spacecraft was off earth-point for two hours and 38 minutes, during which no downlink was obtained.

DSS 12/42 supported the preburn activity, which included special commands and maneuver enable commands. The roll/yaw turns were executed over DSS 42 and the downlink was lost on time. The actual burn occurred during DSS 63/61 view period. The burn was accomplished and the spacecraft returned to earth-point as programmed. To assist in the reacquisition of the X-band downlink, DSS 63 had initialized its Occultation Data Assembly (ODA) and Spectral Signal Indicator (SSI) to search the spectrum for the first indication of the signal. The signal was observed on the SSI and by the X-band receiver, and DSS 63/61 reacquired the downlink telemetrv on time.

Critical commanding followed the reacquisition of the spacecraft downlink, for included in the onboard computer was a Maneuver Recovery Block (MRB) to be executed in case of an anomaly and the spacecraft did not return to earth-point. The MRB would cause the spacecraft to perform a 360-degree roll so that the signal strength could be plotted and the spacecraft pointing could be determined. Once the final pointing position was determined, the spacecraft could be commanded to return to earth-point. To support this activity, DSS 63 had counted down the 100-kW transmitter to be used in case the MRB was executed and the extra uplink power was required to command the spacecraft through the low-gain antenna. The critical commanding was to disable the MRB maneuver within a limited command window. To accomplish the commanding, DSS 63 was required to establish an uplink ramp that would cross through the bandpass of the spacecraft receiver. The spacecraft has a tracking loop capacitor failure that reduces the receiver bandpass, and the receiver frequency varies with changes in compartment temperature. While DSS 63 was ramping the uplink, 30 MRB disable commands were transmitted on 1-minute centers. DSS 61 was ramping also, with the transmitter off, as a backup to DSS 63. The DSS 63 command system alarmed on the first command, and DSS 61 immediately turned its transmitter and command system on, and continued commanding five minutes later. The disable commands were received by the spacecraft and the MRB was disabled. This emergency procedure is documented and is used in support of each spacecraft maneuver.

4. Navigation Cycles. Dual Nav Cycles were supported by the 34/64-meter nets preceding and following the TCM B-8 (see above) to provide the basis and verification of the results of the burn. During a dual Nav Cycle, seven station tracks are provided, whereas during a standard Nav Cycle only four station tracks are provided. The Nav Cycles begin in Australia (southern hemisphere) and continue with Spain/US (northern hemisphere). The Australian stations support the first, middle and last tracks, providing two southern and two northern tracks per cycle.

Three standard Nav Cycles were supported during the period to provide Project Navigation updated data for orbit determination. During processing of the Nav Cycle range data it was discovered that DSS 43's data had a 1-second timing bias. It was necessary for Project Navigation to compensate for the error during processing. The range data from DSS 14 and 63, as well as the doppler data from all three stations, taken during the cycle were good and met Project requirements.

5. Observatory Phase. The Observatory Phase ended at 1003Z on 31 July and the FE-1 phase started. The imaging data received in real-time and during replay were of excellent quality and only a few problems were encountered. DSS 14 had sole plate problems with the antenna, causing the loss of 11 minutes of ultraviolet spectrometer mosaic data of Saturn. DSS 12 experienced a hail storm that ruptured the mylar shield on the S-band horn, but resulted in no impact to the project. Bad weather in Australia caused the loss of four images severely degraded, and 27 images with moderate degradation at DSS 43.

6. **Horizontal and vertical scan maneuvers.** These maneuvers were conducted from 31 July to 1 August. The purpose of the maneuvers was to align the ultraviolet scan field in a vertical position in respect to Saturn, allowing maximum resolution in the horizontal direction as defined by Titan's orbit and then in the horizontal position for the same purpose. The scan platform made a series of slews in each position to scan across the Saturnian system to study the atmospheric emissions.

The horizontal maneuver was supported by DSS 63/61 and the spacecraft stayed on earth-point throughout the maneuver so that telemetry data was received by the stations throughout the period. During the vertical maneuver the spacecraft was off earth-point for six and a half hours. The period up to the loss of the downlink was supported by DSS 14/12, and the reacquisition of the telemetry downlink was supported by DSS 43/42. Included in the DSS 43/42 track was the MRB NO-OP (nonoperational) activity. This activity was the same as that performed after the TCM B-8 (see above), but was accomplished in this case by DSS 43/42. The activity was successfully performed by DSS 43 and the backup capability of DSS 42 was not required.

III. DSN Capabilities

Most of the remaining hardware and software implementation planned for the support of the Saturn Encounter was completed during the first week of July. Also completed were the DSN Operational Verification Tests; proficiency OVTs will continue through the first part of August. The major improvements included installation of X-band low-noise masers and rework of the antennas at the 34- and 64-meter stations. The notable software improvements were for the Metric Data Assembly (MDA) and Occultation Data Assembly (ODA) to support the uplink operation and radio science Near Encounter experiment.